

**ANNEX
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
AND
LAWRENCE LIVERMORE NATIONAL SECURITY, LLC
UNDER
SPACE ACT UMBRELLA AGREEMENT NO. 32993 / SAA2-403582
(ANNEX NUMBER 3)**

ARTICLE 1. PURPOSE

NASA ARC and LLNS, LLC, which operates and manages Lawrence Livermore National Laboratory for the U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA), enter into this Reimbursable Annex Agreement for the purpose of providing the Partner's Flight team with technical support in the utilization of the Configuration Based Aerodynamics (CBAero) Software, Cart3D Software, and Icarus Software, which were developed at NASA ARC. The Partner will benefit from the technical support from NASA subject matter experts in using the CBAero, Cart3D, and Icarus software for LLNS research activities.

The legal authority for this Annex, consistent with the Umbrella Agreement, is in accordance with the Space Act, Other Transactions Authority (OTA), 51 U.S.C. § 20113(e).

ARTICLE 2. RESPONSIBILITIES

A. NASA ARC will use reasonable efforts to:

1. Provide guidance on best practices involved with using CBAERO or Cart3D in control surface workflows.
2. Provide a released CBAERO version that can utilize the US3D Blayer output format for CBAERO anchoring.
3. Support development of workflow in using the equilibrium Cart3D solver that is appropriate for providing accurate equilibrium gas solutions and temperatures in hypersonic flow Mach number regime of interest.
4. Support of development for CBAERO single solution anchoring support with Cart3D Triq files as anchoring input.
5. NASA analysts will assist LLNS in building the latest version of the material and thermal response code Icarus on the LC systems including the following capabilities:
 - a. Parallelization with METIS and HDF5
 - b. All available material property models and tables, both unclassified and ITAR
 - c. Dust erosion algorithm along with support to extend current code to model water droplet erosion of ablative TPS materials
6. NASA analysts will assist LLNS to run Icarus on the existing test suite to verify proper implementation of code and interpretation of various outputs
7. NASA will use reasonable efforts to provide an unclassified example of Icarus's Kuntz Cone geometry and inputs as a test problem
8. NASA will provide a released version of Icarus that is compatible with US3D on the LC systems and will instruct LLNS on methodology of physics coupling and established best practices on running sample ablation case
9. NASA ARC will use reasonable efforts to:

- a. Benchmark coupled Icarus + US3D code vs. US3D + TASC plugin
 - b. Leverage existing Icarus + US3D cases including geometries and flight conditions when readily available and transferrable
 - c. Apply coupled Icarus + US3D on a classified problem at LLNS
10. NASA analysts will assist in providing support for Icarus with dust erosion model for water droplet erosion purposes

B. Partner will use reasonable efforts to:

1. Provide representative geometry (STREAM) and example trajectory for the aerodynamic database in CBAero anchored with Cart3D solutions.
2. Participate in methods development discussions on case selection and interpolation techniques for anchoring that takes into account control surface deflections.
3. Provide input on the output functionals for AMR that are appropriate for providing accurate equilibrium gas solutions and temperatures in hypersonic flow Mach number regime of interest
4. Running US3D / TASCC

ARTICLE 3. SCHEDULE AND MILESTONES

The planned major milestones for the activities for this Annex defined in the "Responsibilities" Article are as follows:

Milestones	Estimated Completion Date
Complete Icarus build on LC Systems (including METIS, HDF5, material property tables, etc.)	6/30/2023
Provide CBAERO version v.6.X to LLNS	6/30/2023

ARTICLE 4. FINANCIAL OBLIGATIONS

A. Partner agrees to reimburse NASA an estimated cost of \$310,907 for NASA to carry out its responsibilities under this Annex. Each payment shall be marked with Ames Research Center, Annex Three, SAA2-403582-3.

B. NASA will not provide services or incur costs beyond the current funding. Although NASA has made a good faith effort to accurately estimate its costs, it is understood that NASA provides no assurance that the proposed effort under this Annex will be accomplished for the estimated amount. Should the effort cost more than the estimate, Partner will be advised by NASA as soon as possible. Partner shall pay all costs incurred and have the option of canceling the remaining effort, or providing additional funding in order to continue the proposed effort under the revised estimate. Should this Annex be terminated, or the effort completed at a cost less than the agreed-to estimated cost, NASA shall account for any unspent funds within one year after completion of all effort under this Annex, and promptly thereafter, at Partner's option return any unspent funds to Partner or apply any such unspent funds to other activities under the Umbrella Agreement. Return of unspent funds will be processed via Electronic Funds Transfer (EFT) in accordance with 31 C.F.R. Part 208 and, upon request by NASA, Partner agrees to complete the Automated Clearing House (ACH) Vendor/Miscellaneous Payment Enrollment Form (SF 3881).

ARTICLE 5. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

- A. Data produced under this Annex which is subject to paragraph C. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement will be protected for the period of one year.
- B. Under paragraph H. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement, Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data provided.
 - 1. Background Data: The Disclosing Party's Background Data, if any, will be identified in a separate technical document.
 - 2. Third Party Proprietary Data: The Disclosing Party's Third Party Proprietary Data, if any, will be identified in a separate technical document.
 - 3. Controlled Government Data: The Disclosing Party's Controlled Government Data, if any, will be identified in a separate technical document.
 - 4. The following software and related Data was provided to Partner under a separate Software Usage Agreement (i.e., Partner already received the following software and related Data under a previous Software Usage Agreement entered into in support of work under DOE Management and Operating Contract DE-AC52-07NA27344:
 - i. ARC-14275-1: Automated Triangle Geometry Processing for Surface Modeling and Cartesian Grid Generation (Cart3D) under SUA2-14275-15093
 - ii. ARC-15819-1: CBAero under SUA2-15819-15079
 - iii. ARC-18207-1: Icarus under SUA2-18207-15000

ARTICLE 6. TERM OF ANNEX

This Annex becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or one (1) year from the Effective Date, whichever comes first, unless such term exceeds the duration of the Umbrella Agreement. The term of this Annex shall not exceed the term of the Umbrella Agreement. The Annex automatically expires upon the expiration of the Umbrella Agreement.

ARTICLE 7. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Annex by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 8. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Annex.

Management Points of Contact

NASA Ames Research Center

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Technical Points of Contact

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ARTICLE 9. MODIFICATIONS

Any modification to this Annex shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Modification of an Annex does not modify the terms of the Umbrella Agreement.

ARTICLE 10. SIGNATORY AUTHORITY

The signatories to this Annex covenant and warrant that they have authority to execute this Annex. By signing below, the undersigned agrees to the above terms and conditions.

**NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
AMES RESEARCH CENTER**

**LAWRENCE LIVERMORE
NATIONAL SECURITY, LLC**

BY: _____

Dr. Rupak Biswas

Director of Exploration Technology

DATE: _____

Gabrielle

Luisa Keller

BY: _____

Gabrielle Keller

Contract Analyst

DATE: 08/24/2022

Digitally signed by
Gabrielle Luisa Keller
Date: 2022.08.24
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